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EXPERIMENTAL STUDIES IN DEVELOPMENT.

Einführung in die Experimentelle Entwickelungsgeschichte. By Prof. Otto Maas. Pp. xvi+203. (Wiesbaden: J. F. Bergmann, 1903.) Price 7 marks.

ONE of the most fascinating branches of biological inquiry is that concerned with the investigation of those factors that underlie organisation and determine the course of development of the individual from the egg to its adult condition. From old time the question as to why a hen's egg should give rise to a fowl and not to a lizard or a mammal is one that has invited but never been met with a satisfactory answer, any more than the agencies have been recognised that direct and determine the orderly series of cell divisions culminating in the production of a specific form with all its marvellous organs and complex tissues.

It was formerly believed that, in some mysterious fashion, the actual structure of the adult lay concealed in the egg, much as the flowers of some of our trees can be detected in a resting condition, while it is still winter, by stripping off the bud scales that enfold them. When this view had been shown to be both logically and as a matter of experience untenable, the doctrine of epigenesis displaced it, but this, too, failed to provide a satisfactory basis on which a comprehensive explanation of the phenomena could be built up. Thus in quite recent times a revival of the evolution-theory has arisen, not, indeed, in the older and cruder form, but as promulgated by Weismann and his followers it has appeared to throw light on, and indicate a reason for, the remarkable phases passed through by the cell-nucleus during its division, and at the same time it took cognisance of the extraordinary phenomena that precede and accompany sexual reproduction. It has, however, been subjected to strenuous criticism, and weighed in the balance it, like its predecessors, has been found wanting.

The centre of gravity of current investigation is shifting again from the nucleus to the extra nuclear cell-protoplasm (cytoplasm). As the result of experiment, it has become certain that this part of the cell has to be reckoned with in any theories that pretend to group the facts together, and it is pretty certainly a good deal more than a mere nutritive substance which simply furnishes the nucleus with substances that may enable the latent possibilities of the latter to be converted into actual entities having the specific quality of form and other properties. The old definition of the cell as a mass of protoplasm containing a nucleus is still found to hold good, but the parts played by the two constituents admit of more precise delimitation than was the case even a few years ago.

A step of no small importance was made when it was discovered that by centrifugalising fertilised frogs' eggs, so as to drive the yolk up to one end of the egg, the course of segmentation becomes artificially meroblastic. Thus a condition is produced which is actually met with in many eggs (*e.g.* of molluscs) in which the yolk is present in large quantity and is unequally distributed.

Still more important was the further discovery that the first few blastomeres of a fertilised segmenting egg could be separated and induced to continue their development as isolated individuals. For this afforded an opportunity of deciding whether the organism was the product of its cells, or the cells of the organism The results strongly point in the latter direction. The same conclusion is reached from the experiments of Hertwig, who by compression succeeded in causing the early cells of the embryo to take up abnormal positions, but the organisation of the larva did not then follow the cell-arrangement, but superseded it. The experiments with isolated blastomeres do not give the same results in all cases. Thus, if they are isolated at the first segmentation of the ovum of an Amphioxus, each gives rise to a small but perfect embryo, and thus behaves as though it were a small egg. In the sea-urchins, the isolated cells at first continue to develop as though the missing part were still present, that is, they give rise to *partial* embryos. But very soon the form of the normal embryo at the corresponding stage is made good, and small but perfect larvæ may result. Yet another example is seen in *Beroë* and some other animals, in which, whilst segmentation at first goes on as though the isolated part were a small egg, at later stages the embryo exhibits various structural defects.

It is very important to notice that these various types of behaviour do not depend on the nuclei. It might be thought that as the small larvæ, at first often defective (sea-urchins), had arisen from cells the nuclei of which had arisen by division from that of the original ovum, the defective character should be correlated directly with this fact. The nuclei might be supposed to have diverged in character, so that, for example, that of one cell contained in itself the latent potentialities of a definite half or other portion of the embryo. But such an explanation is directly contradicted by the facts as shown in Amphioxus, and would not be easily reconciled either with such cases as that of *Beroë* or by the commonly occurring modification of the further processes whereby small, but otherwise perfect, larvæ may arise in spite of the initially different mode of segmentation. Moreover, it has been shown that when freshly fertilised eggs are shaken so as to separate off portions of the cytoplasm *before* segmentation, modifications are produced very similar to those that occur in separated blastomeres. This appears to tell conclusively in favour of the great importance of the cytoplasm as a factor in determining the progress of development. In fact the egg, as has been well said, is itself an organism. Not that the parts characteristic of the adult are there present *in esse*, but the *substance*, the primordial materials out of which the early structures are severally built up, is actually present in the unsegmented egg.

There is some direct evidence available on this point. In many eggs differences of colour or texture can be seen to occupy definite positions in the egg, and if it is rotated these zones often rearrange themselves,

apparently under the influence of gravity, so as to take up the same configuration as before. This fact is highly significant in connection with the production of perfect and normal embryos, although the positions of the earlier formed blastomeres may have been so artificially shifted that their cell descendants occupy abnormal positions in the otherwise normal larva.

The correctness of this general interpretation is also supported by the readiness with which partially separated blastomeres will form double embryos. The two masses of nearly isolated cytoplasm thus develop independently, the lack of adequate contact or continuity between the corresponding parts of the two cells being apparently responsible for the monstrosity. An instructive comparison is afforded by a consideration of the results of artificially induced union of originally separate blastomeres of similar order. If these are approximated so that the axes of the different substances in each are parallel, they segment as one organism, that is, the cell division is coordinated. If, however, the axes are divergent, then each blastomere continues to segment more or less independently, and monsters of various degrees result.

These embryos, arising from isolated blastomeres of the first or following cell-generations, and also those originating from the fusion of previously isolated ones, concur in one remarkable characteristic, viz. the size of the larva at any given stage is proportionate to the relation between the cell from which the embryo actually arose, and the ovum of the species. Thus embryos from either of the first two blastomeres are half the normal size, and so on.

This variation in size is effected by a corresponding reduction in the *number* of cells that go to make up the different parts or regions of the whole, and not by a difference in their *size*. At first sight this circumstance might seem to favour the hypothesis of "unequal" nuclear divisions, *i.e.* the production of daughter cells with constantly segregating potentialities. But any such explanation is at variance both with the facts of development, taken as a whole, and with those of regeneration as well. What the evidence does seem to point to is the existence of definite substances present in the cytoplasm, and that these, though not actually representing the several organs *in parvo*, nevertheless do represent substances necessary to the formation of these organs—a very different thing. It is, then, intelligible why an organism that is left with only half the amount of any one such substance can only produce half the number of cells during cleavage; and a working hypothesis can be formed as to why regeneration is possible in some cases whilst it is apparently excluded in others. There exist strong grounds for believing that the formative stimuli leading to organogenetic development normally reside in the nucleus, but unless the substances capable of responding or of cooperating in the response to a stimulus are present, a normal result need no more be expected than that a printing machine should be capable of turning out a printed page unless the type had been inked.

But though the ground is being broken, much will have to be done before we are in a position to give a satisfactory explanation of the phenomena of development and regeneration. At present it is sufficient to analyse and investigate experimentally the agencies that are concerned in these and other vital processes; we shall thus, and only thus, be able to elevate the surviving elements of existing hypotheses to the rank of well-founded theory.

The volume by Dr. Maas will form a useful source of information for those who may desire to know what is being done in these directions. Its author does not claim to have treated the subject exhaustively, and, indeed, we could wish the sections dealing with the chemical and physical aspects of the matter had been expanded. Nor will the reader who is familiar with the work of Driesch, Roux and others perhaps find much recorded that will be new to him, but the presentation of the subject-matter is, on the whole, judicious and critical. The work covers a wider range than might be gathered from the general tenor of the present article, but as the whole subject deserves more general attention than it receives, it appeared to be more useful to attempt to indicate some of the actual results and the questions arising from them, than merely to give a discursive synopsis of a book that should be read by all who are interested in the more important biological problems of the present day.

J. B. F.

THE ALKALI AND CHLORINE INDUSTRY.

La Grande Industrie Chimique Minerale. By E. Sorel, Ancien Ingénieur des Manufactures de l'État. Pp. 679. (Paris: C. Naud, 1904.) Price 15 francs

THIS work is concerned with the alkali industry and with those manufactures which naturally group themselves around it. That is to say, it treats of soda and potash, the chief salts of sodium and potassium, the halogens, and the principal industrial compounds of the latter, such as bleaching-powder and the chlorates.

The point of view adopted is essentially that of the manufacturing chemist or chemical engineer. Generally, however, the treatment is rather broader than this might indicate. Thus the history of a process or the growth of an industry is often outlined, and the mode of occurrence of the raw materials used is described more or less fully. As further illustrating the same point we note that, in connection with hydrochloric acid, several pages are devoted to a discussion of the effects which the acid vapours discharged from chemical works produce upon the vegetation of the locality. This, again, is followed by a chapter in which the general principles of the condensation of vapours are discussed from the thermodynamical standpoint. Nor does the author disdain to lighten his pages with occasional items of miscellaneous—not to say trivial—information. We learn, for instance, that in Central Africa "les enfants courent après un morceau de sel, comme les nôtres après un bon-bon."

The salt industry is dealt with in the opening chapter. There is a good description of the production of salt from sea-water, and some particulars of the salt deposits of Cordova, Lorraine, Stassfürt, and Transyl-